S-5/PHSH/DSE-I/21

TDP (Honours) 5th Semester Exam., 2021

PHYSICS

(Honours)

PAPER : (DSE–I)

Full Marks : 80 *Time* : 3 Hours

The figures in the margin indicate full marks.

Candidates are required to give their answers in their own words as far as practicable.

SECTION—A

1. Answer *any* **eight** questions of the following : 2×8=16

(a) Define nuclear magnetic moment.

(b) What is the analogy between a nucleus and a liquid drop?

(c) What are magic and semimagic numbers in nuclear physics?

(d) How a cyclotron can be used to accelerate electron?

(e) What do you mean by reaction rate of a nuclear reaction?

(f) What do you understand by 'internal conversion'?

(g) What is 'mirror nuclei'? Give examples.

(h) What do you mean by fine structure of α-ray spectrum?

(e) Identify the unknown particle in the following reaction.

$$k^- + p \rightarrow k^+ + ?$$

(f) Explain the phenomenon of inverse β-decay.

(g) What is meant by range of α-particles?

(f) Define antiparticles with examples.

SECTION—B

There are four questions from Question No. 2 to Question No.5. Answer either *(a) or (b)* from each question.

Answer the following questions : 16×4=64

2. *(a)* *(i)* Explain the terms 'mass defect' and 'binding energy' of a nucleus.

(ii) Calculate the binding energy per nucleon for the deuteron. Given $m_n = 1.675\times10^{-27}$ kg, $m_p = 1.672\times10^{-27}$ kg, $m_D = 3.343\times10^{-27}$ kg, $c = 3\times10^8$ m/sec.

(iii) Write a short note on "electric quadrupole moment of the nucleus".

(iv) Explain the salient features of the liquid drop model. List out the various assumptions made while making the model. (3+4)+3+(3+3)=16

(OR)

(b) (i) Derive the expression for semi-empirical binding energy formula.

(ii) Using the semi-empirical binding energy formula, calculate binding energy of $^{40}Ca_{20}$.

(iii) Write a short note on the "size of the nucleus".

(iv) Explain the salient features of the shell model of the nucleus. How does it explain the magic numbers in the ground state of the nucleus? 5+2+2+(3+4)=16

3. *(a)* *(i)* State the condition of α-decay and explain why in a α-decay of a radioactive nuclide, the K.E. of the emitted α-particles is a little less than the disintegration energy.

(ii) "Electrons cannot exist as an integral part of the nucleus." Justify the statement.

(iii) Discuss how neutrino hypothesis explain the β-decay and β-ray energy spectrum.

(iv) Write the characteristics of γ-radiation.

(4+2)+3+5+2=16

(OR)

(b) *(i)* Derive an expression for the Q-value of the reaction $X(a,b)Y$ in terms of K.E. of the incident and product particles and masses at the various particles and nuclei. Assuming the target nucleon to be initially at rest in the laboratory.

(ii) Discuss the compound nucleus theory at nuclear reactions.

(iii) The bombardment of lithium with protons gives rise to the reaction ${}^{7}_{3}Li + {}^{1}_{1}H \rightarrow {}^{4}_{2}He + {}^{4}_{2}He +$ Energy. The atomic masses of lithium, hydrogen and helium are 7.016 amu, 1.008 amu and 4.004 amu respectively. Find the value of energy released in this reaction.

[Continued]

(iv) Explain 'nuclear reaction cross-section'.

(v) Define attenuation and absorption co-efficient of γ-ray when it passes through matter. 4+3+3+2+2+2=16

4. (a) (i) Find the expression of momentum gained by the electron of the medium when a heavy particle is passing through the medium and interact with that electron.

(ii) Explain pair production and annihilation of electron-positron pair.

(iii) Explain the working principle of G-M counter with a neat diagram.

(iv) An ionisation chamber is connected to an electrometer of capacitance 0.5 pF and voltage sensitivity of 4 divisions per volt. A beam of α-particle causes a deflection of 0.8 divisions. Calculate the number of ion pair required and the energy of the α-particle. Given that 1 ion pair requires energy of 35 eV and $e = 1.6\times10^{-19}$ coulomb. 5+3+5+3=16

(OR)

(b) (i) What is Compton effect? Derive the expression for Compton Shift.

(ii) Write a short note on 'Cherenkov radiation'.

(iii) With a clear diagram explain the working principle of 'photomultiplier tube'.

(iv) α-particles of energy 5 MeV pass through an ionisation chamber at the rate of 10 per second. Assuming all the energy is used in producing ion pairs, calculate the current produced. (35 eV is required for producing an ion pair and e = 1.6×10^{-19} coulomb)

(1+4)+3+5+3=16

5. (a) (i) Describe the working principle of a Van de Graaff generator. Write its advantages as well as disadvantages.

(ii) Explain 'strangeness' and 'hypercharge' in connection with elementary particles.

(iii) Choose the reaction allowed or not

(1) $K^- + P \rightarrow \sum^- + \pi^+$

(2) $\bar{P} + P \rightarrow \pi^+ + \pi^-$

(4+3)+(3+3)+3=16

OR

(b) (i) What are elementary particles? Mention different types of elementary particles and their families.

(ii) With a neat sketch, discuss the principle and working of a cyclotron.

(iii) What are baryon numbers and strangeness numbers?

(iv) Write a short note on Quark model.

(1+4)+5+3+3=16

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S-5/PHSH/DSE-II/19

TDP (Honours) 5th Semester Exam., 2019

PHYSICS

(Honours)

PAPER - DSE - II

(Advanced Mathematical Physics)

Full Marks : 80 Time : 3 Hours

The figures in the margin indicate full marks.
Candidates are required to give their answers in their own words as far as practicable.

1. Answer any *eight* questions : 2×8=16

(i) What is the value of 'a' if $B = \begin{bmatrix} 1 & 4 \\ 2 & a \end{bmatrix}$ is a singular matrix ?

(ii) Find the eigen value of the matrix

$$\begin{bmatrix} 2 & -1 & 1 \\ -1 & 2 & -1 \\ 1 & -1 & 2 \end{bmatrix}$$

[Turn Over]

(iii) State the rule by which a covariant tensor can be transformed. Write properties of Kronecker delta.

(iv) Find the probability of getting 4 heads in six tosses of a fair coin.

(v) Write the range of probability distribution for all possible values of a random variable. If the standard deviation of Poisson distribution is $\sqrt{2}$, then find probability for $r = 2$.

(vi) If α be a non-zero vector element in V and a, b are scalars in F, then what will be relation between a and b?

$\{\alpha_i\}$ set of vectors are linearly dependent or not?

(vii) If A^i and B_j are the contravariant and covariant tensor of rank 1, then what will be $A^i B_j$?

(viii) Write the inverse of '$-i$' in the multiplicative group $\{1, -1, i, -i\}$.

(ix) Find $\in_{ilm} \in_{jlm}$. What will be the identity element in the group $G\{2, 4, 6, 8\}$ under multiplication modulo 10?

(x) The set of integers 'z' with the binary operation '$*$' defined as $a*b = a + b + 1$ for $a, b \in z$ is a group. Write the identity element of this group.

Section - B

Answer the following questions : 16×4=64

2. (a) (i) Show that every square matrix can be uniquely expressed as the sum of a symmetric and skew symmetric matrix.

(ii) State and explain Cayley-Hamilton theorem.

(iii) Find the eigen values and eigen vectors of the matrix

$$A=\begin{bmatrix}3 & 1 & 4\\ 0 & 2 & 0\\ 0 & 0 & 5\end{bmatrix}$$

(iv) Distinguish between symmetric and skew symmetric matrices with example.

4+4+4+4

Or

(b) (i) Show that the matrix

$$A=\frac{1}{3}\begin{bmatrix}1 & 2 & 2\\ 2 & 1 & -2\\ -2 & 2 & -1\end{bmatrix}$$

is orthogonal in character.

[Turn Over]

(ii) Solve the following equations with the help of matrices —

$$x + y + z = 3$$
$$x + 2y + 3z = 4$$
$$x + 4y + 9z = 6$$

(iii) Write the condition of a matrix to be a Hermitian. Show that the eigen values of a Hermitian matrix are real.

(iv) Find the values of x, y, z and a which satisfy the matrix equation :

$$\begin{bmatrix} x+3 & 2y+x \\ z-1 & 4a-6 \end{bmatrix} = \begin{bmatrix} 0 & -7 \\ 3 & 2a \end{bmatrix}$$

3+4+5+4

3. (a) (i) Write the condition for two vectors to be linearly dependent. Show that the vectors of the set (1, 2, 3, 4), (1, 0, 2, 1), (2, –1, 4, 1), (–1, 3, 0, 4) are linearly dependent.

(ii) What is contravariant and co-variant tensors? Show that the law of transformation for a contravariant vector is transitive.

(iii) Define vector space and its basic with example.

(2+5)+(2+3)+4

Or

(b) (i) State and explain quotient law of a tensor.

(ii) If $A_{\lambda\mu}$ is a skew symmetric tensor, show that $\left(B^{\mu}_{\gamma} + B^{\sigma}_{\tau} + B^{\mu}_{\tau} + B^{\sigma}_{\gamma}\right) A_{\mu\sigma} = 0$.

(iii) If a mixed tensor A^{i}_{j} is symmetric in the x^{i} co-ordinate system, find out whether it will be symmetric in any other co-ordinate system or not.

(iv) Find the coordinates of the vector $\alpha = (2, 3, 1)$ relative to the basis

$\beta = \{(1, 1, 1), (1, 1, 0), (0, 1, 0)\}$.

4+4+4+4

4. (a) (i) Under what condition a group will be a cyclic group? Write down the characteristics of a cyclic group.

(ii) Show that the C_{4v} is homomorphic to the group (1, –1) under multiplication. Also show that this 4 to –1 homomorphic mapping can be established in 3 distinct ways.

[Turn Over]

(iii) What do you mean by finite and infinite group? Define order of such group.

(2+5)+(2+3)+4

Or

(b) (i) What do you mean by homomorphism and isomorphism of groups? Write down their properites.

(ii) Show that every subgroup of index 2 is a normal subgroup.

(iii) Obtain the direct products of all the irreducible representation of the group C_{3v} and reduce them into direct sums of the irreducible representation.

(iv) What do you mean by Kernal of the group? Explain with example.

(2+4)+3+4+3

5. (a) (i) State and proof Baye's theorem of probability.

(ii) In a normal distribution, 31% of items are under 45 and 8% are over 64. Find the mean and standard deviation of the distribution.

(iii) An urn contains 10 black balls and 10 red balls. What is the probability of drawing the two balls of the same colour.

(iv) Explain conditional probability with example.

(2+3)+4+4+3

Or

(b) (i) What is co-variance? Show that the co-variance of two independent variables is always zero.

(ii) What is Poisson's distribution? Find the expression for it.

(iii) What is the probability that a leap year selected at random contains 53 Sundays?

(iv) What do you mean by "probability distribution of a random variable"? Name three important probability distribution.

(2+2)+(2+3)+4+3